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Kawaguchi et al.

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[54] **NEEDLE BAR STOPPER FOR USE IN A SEWING MACHINE**

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[30] **Foreign Application Priority Data**

Nov. 20, 1996 [JP] Japan 8-309572

[51] **Int. Cl.**[6] **D05B 69/18**

[52] **U.S. Cl.** **112/277**; 112/221

[58] **Field of Search** 112/275, 277, 112/273, 271, 274, 445, 221

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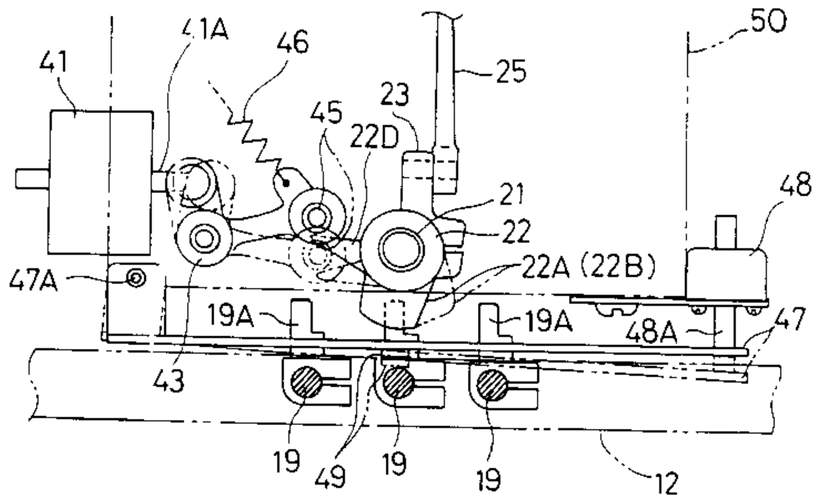
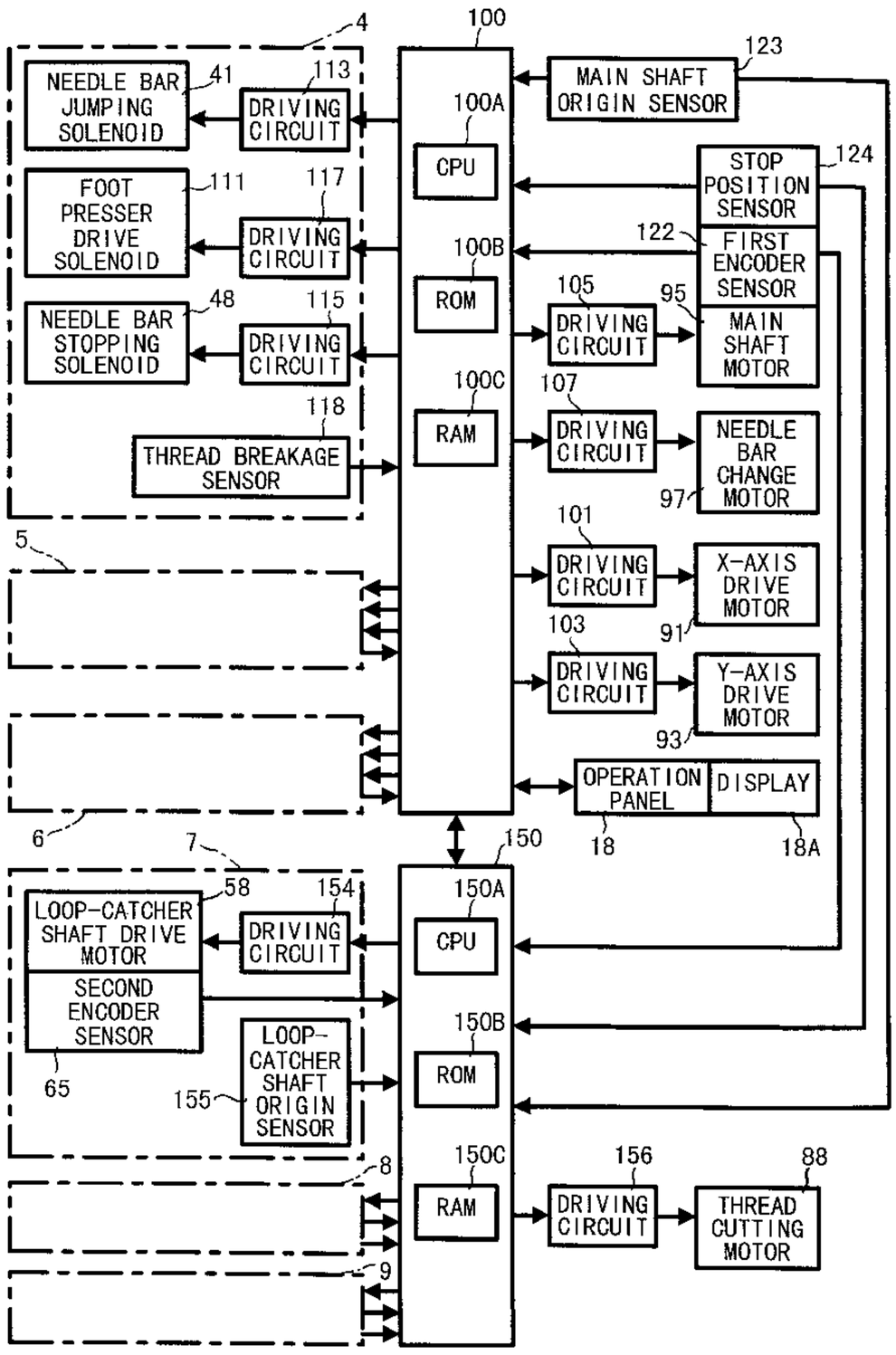
Attorney, Agent, or Firm—Oliff & Berridge, PLC

[57] **ABSTRACT**

A needle bar stopper is provided in a sewing machine having a main shaft and a needle bar which moves vertically upon reception of a driving force from the main shaft. The needle bar stopper comprises a transmission prohibiting unit, including a needle bar stopping solenoid, which prohibits transmission of the driving force from the main shaft to the needle bar and a braking unit, including a needle bar stopping solenoid, which applies a braking force to the needle bar when transmission of the driving force is prohibited by the transmission prohibiting unit. The needle bar stopper can stop the needle bar reliably by use of the braking unit.

18 Claims, 8 Drawing Sheets





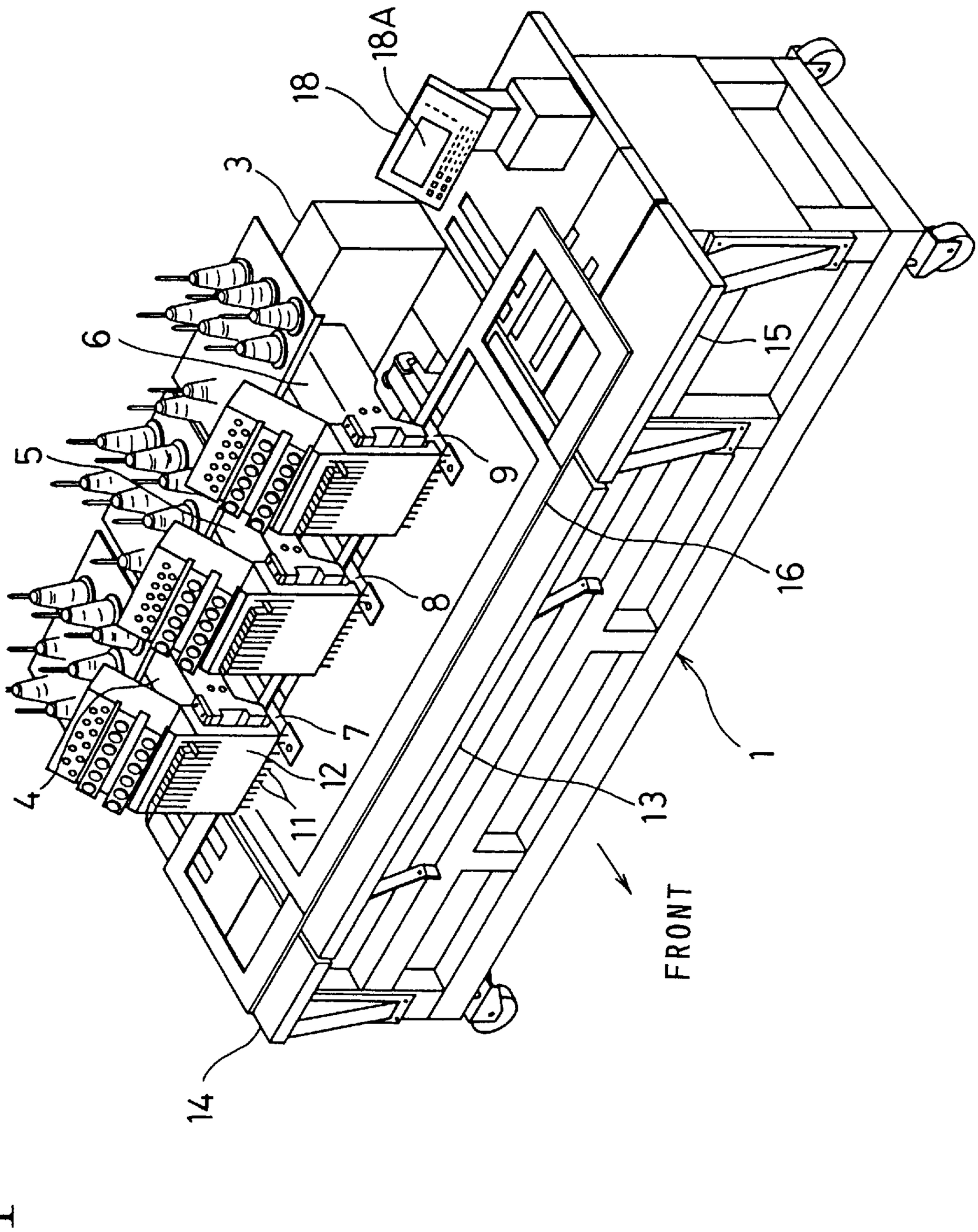


Fig.1

Fig.2

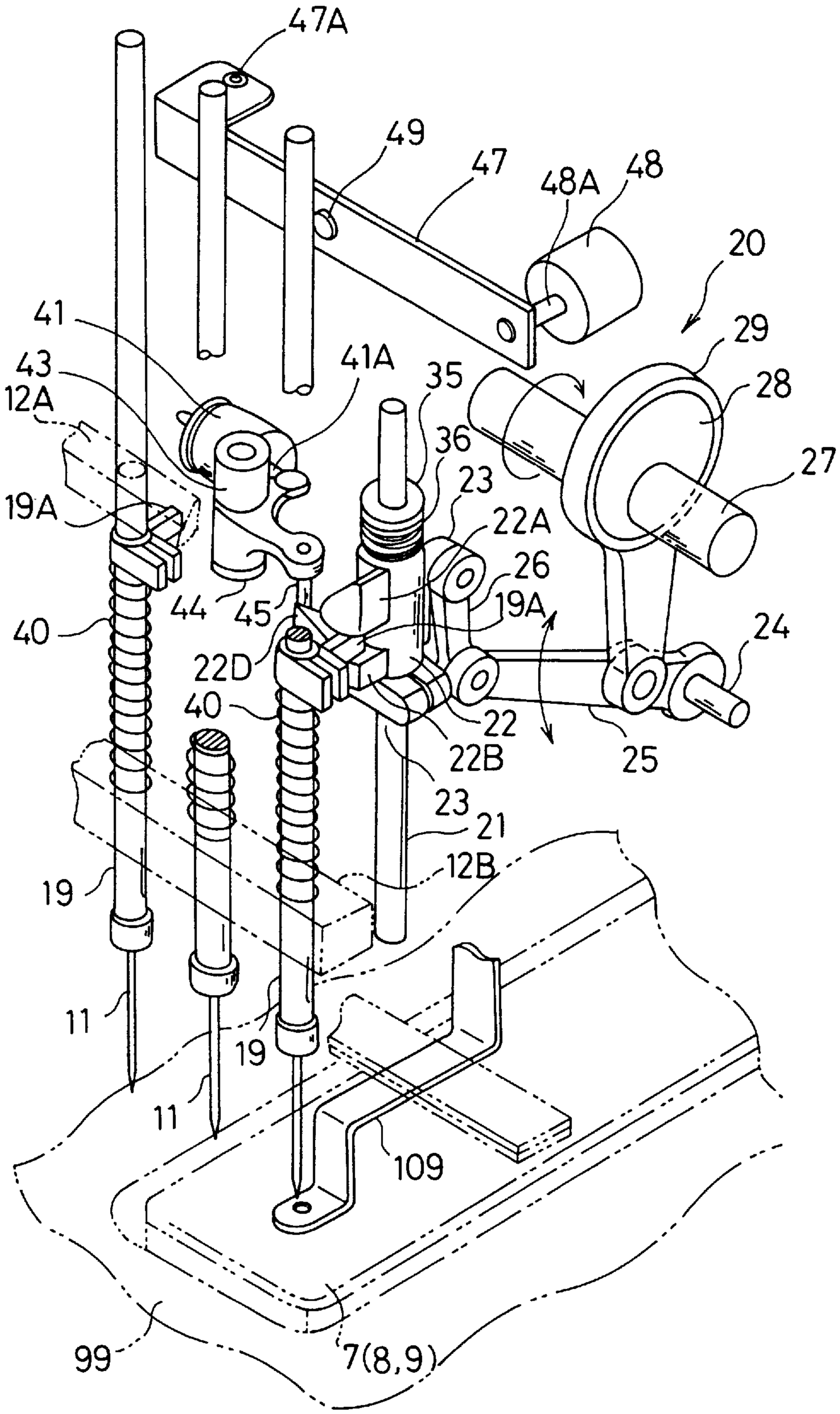

47A
49
47
48A
48
20
41
29
43
41A
35
28
12A
36
27
23
19A
22A
26
19A
24
44
45
40
22D
40
22
22B
25
23
21
12B
19
11
19
11
109
99
7(8,9)

Fig.3

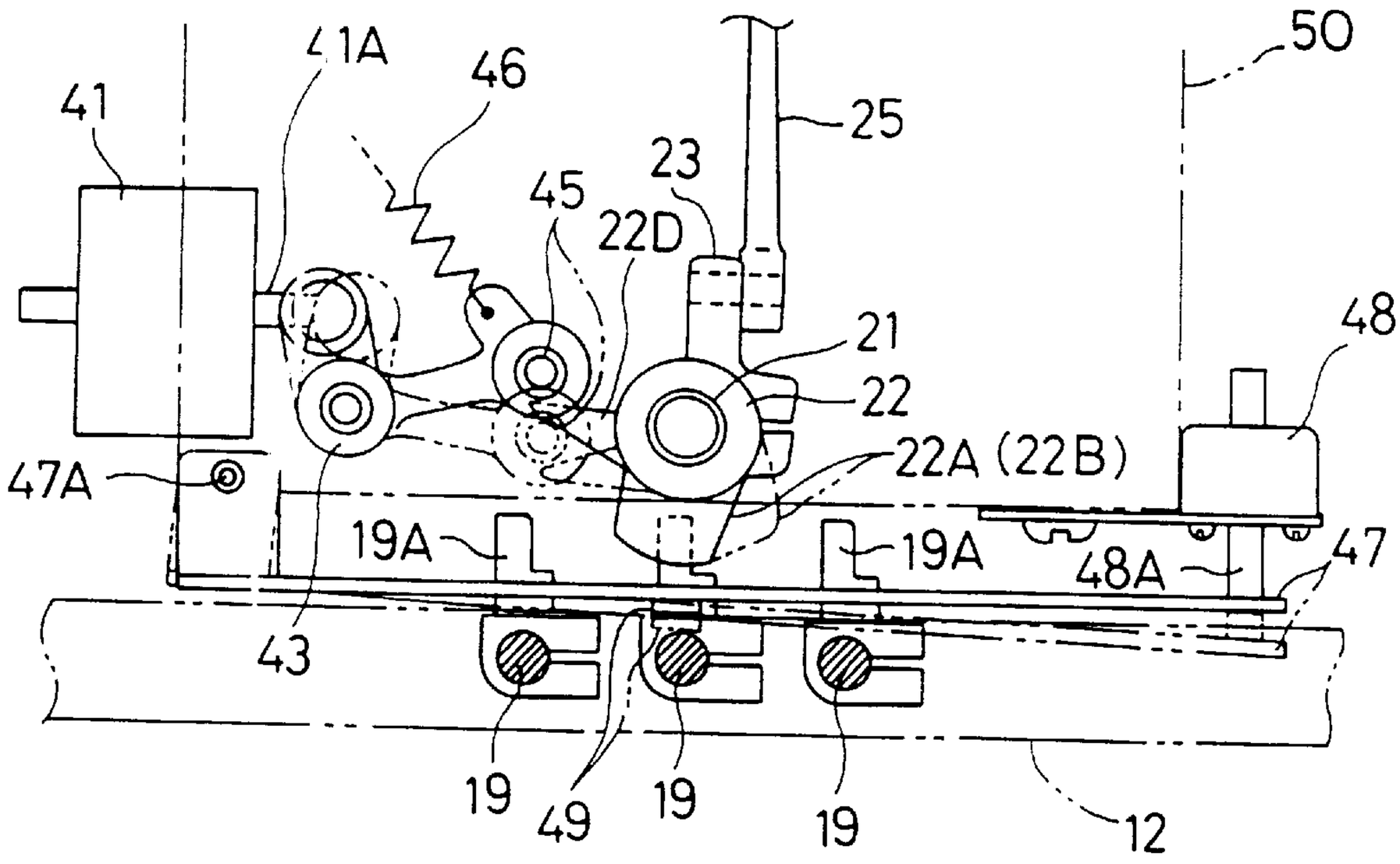

41
41A
46
45
22D
23
25
50
21
22
48
22A (22B)
47A
19A
19A
48A
47
43
19
49
19
19
12

Fig.4

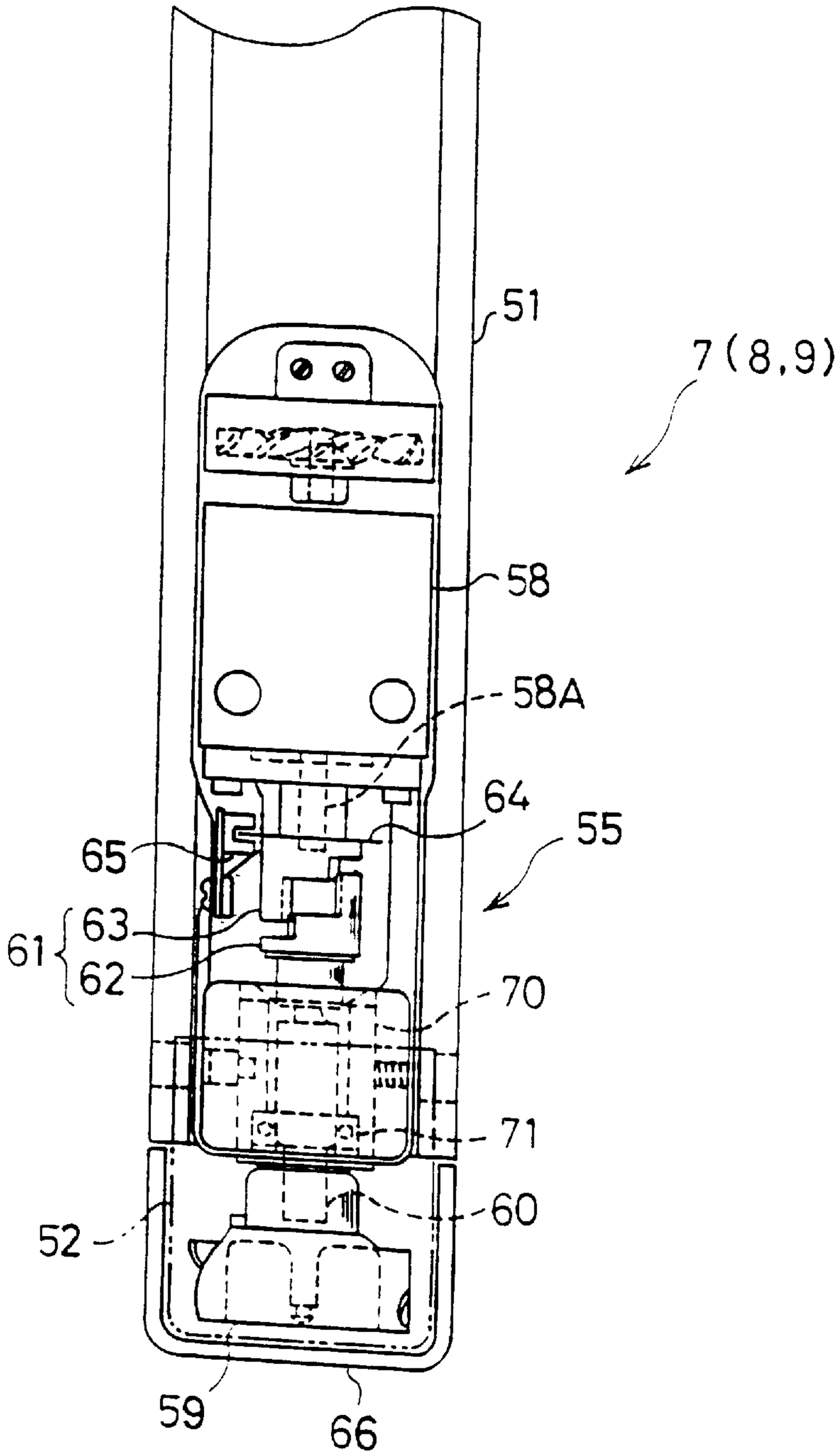


Fig. 5

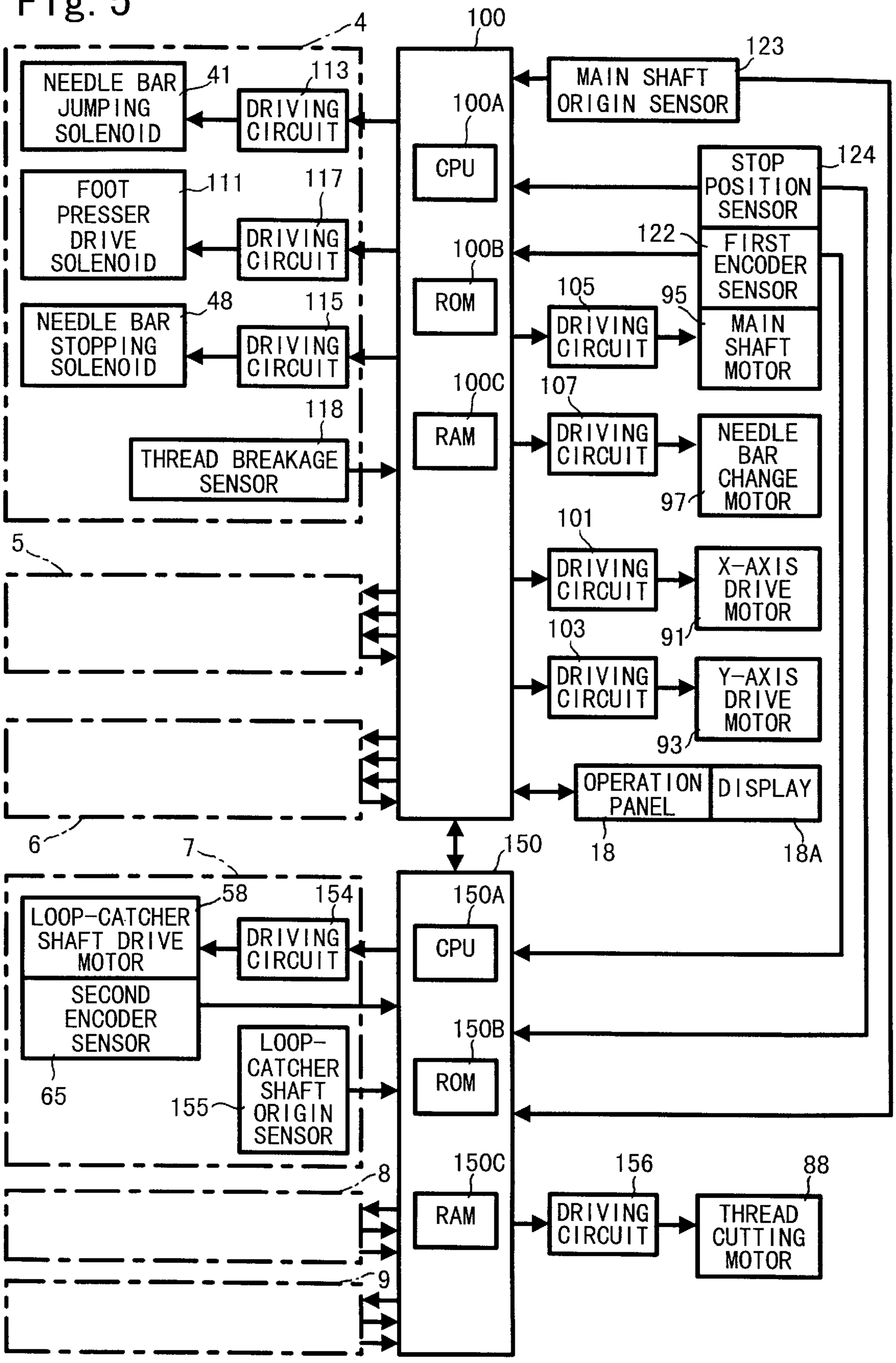

4
100
123
NEEDLE BAR JUMPING SOLENOID
41
113
DRIVING CIRCUIT
100A
MAIN SHAFT ORIGIN SENSOR
CPU
124
STOP POSITION SENSOR
FOOT PRESSER DRIVE SOLENOID
111
117
DRIVING CIRCUIT
122
100B
FIRST ENCODER SENSOR
ROM
105
DRIVING CIRCUIT
95
MAIN SHAFT MOTOR
NEEDLE BAR STOPPING SOLENOID
48
115
DRIVING CIRCUIT
100C
107
RAM
DRIVING CIRCUIT
NEEDLE BAR CHANGE MOTOR
97
118
THREAD BREAKAGE SENSOR
101
DRIVING CIRCUIT
X-AXIS DRIVE MOTOR
91
103
DRIVING CIRCUIT
Y-AXIS DRIVE MOTOR
93
OPERATION PANEL
DISPLAY
18
18A
5
6
7
150
58
154
150A
LOOP-CATCHER SHAFT DRIVE MOTOR
DRIVING CIRCUIT
CPU
SECOND ENCODER SENSOR
65
150B
LOOP-CATCHER SHAFT ORIGIN SENSOR
155
ROM
8
150C
156
88
RAM
DRIVING CIRCUIT
THREAD CUTTING MOTOR
9

Fig. 6

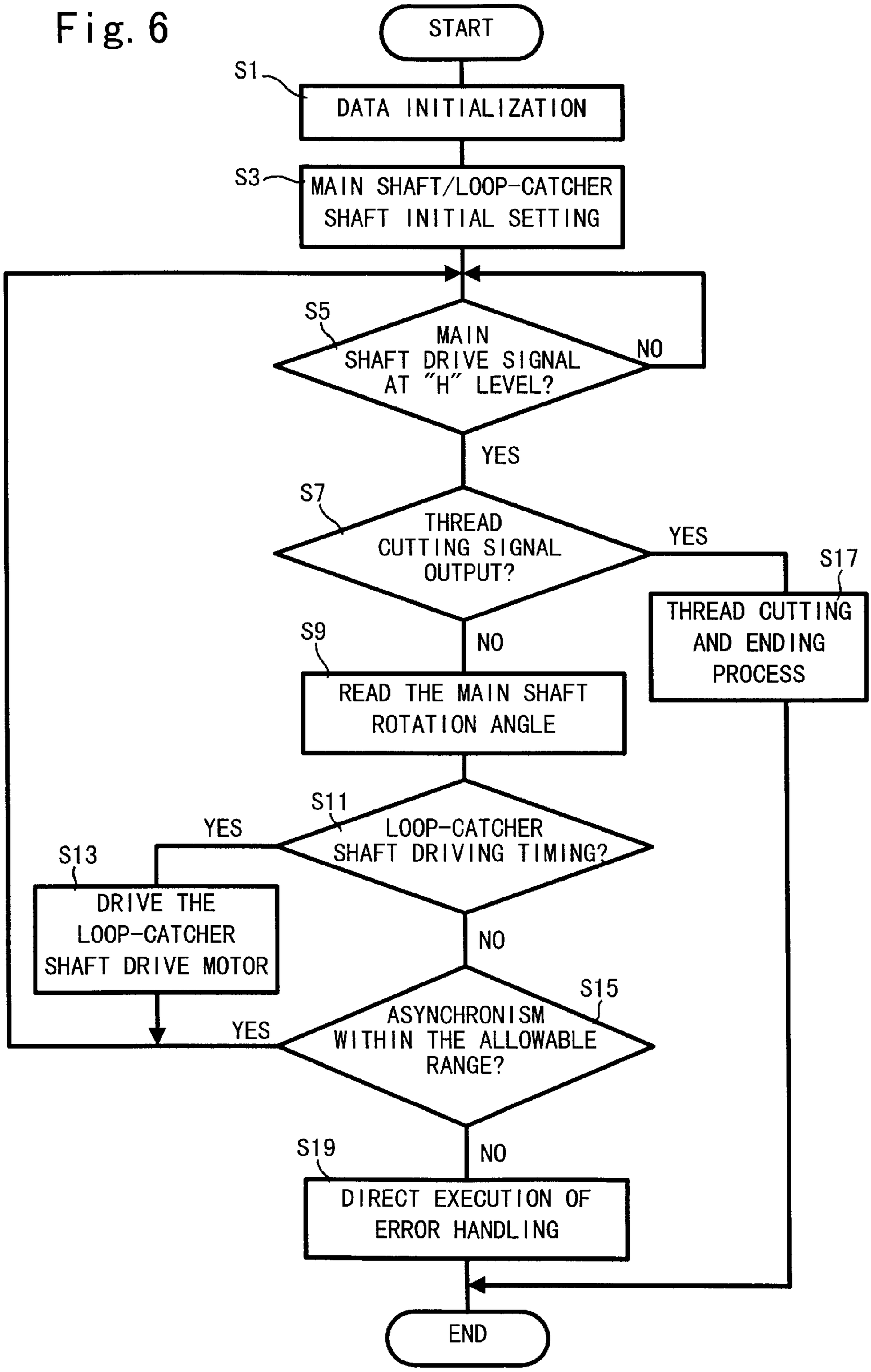

START
S1
DATA INITIALIZATION
S3
MAIN SHAFT/LOOP-CATCHER SHAFT INITIAL SETTING
S5
MAIN SHAFT DRIVE SIGNAL AT "H" LEVEL?
NO
YES
S7
THREAD CUTTING SIGNAL OUTPUT?
YES
S17
THREAD CUTTING AND ENDING PROCESS
NO
S9
READ THE MAIN SHAFT ROTATION ANGLE
S11
LOOP-CATCHER SHAFT DRIVING TIMING?
YES
S13
DRIVE THE LOOP-CATCHER SHAFT DRIVE MOTOR
NO
S15
ASYNCHRONISM WITHIN THE ALLOWABLE RANGE?
YES
NO
S19
DIRECT EXECUTION OF ERROR HANDLING
END

Fig. 7

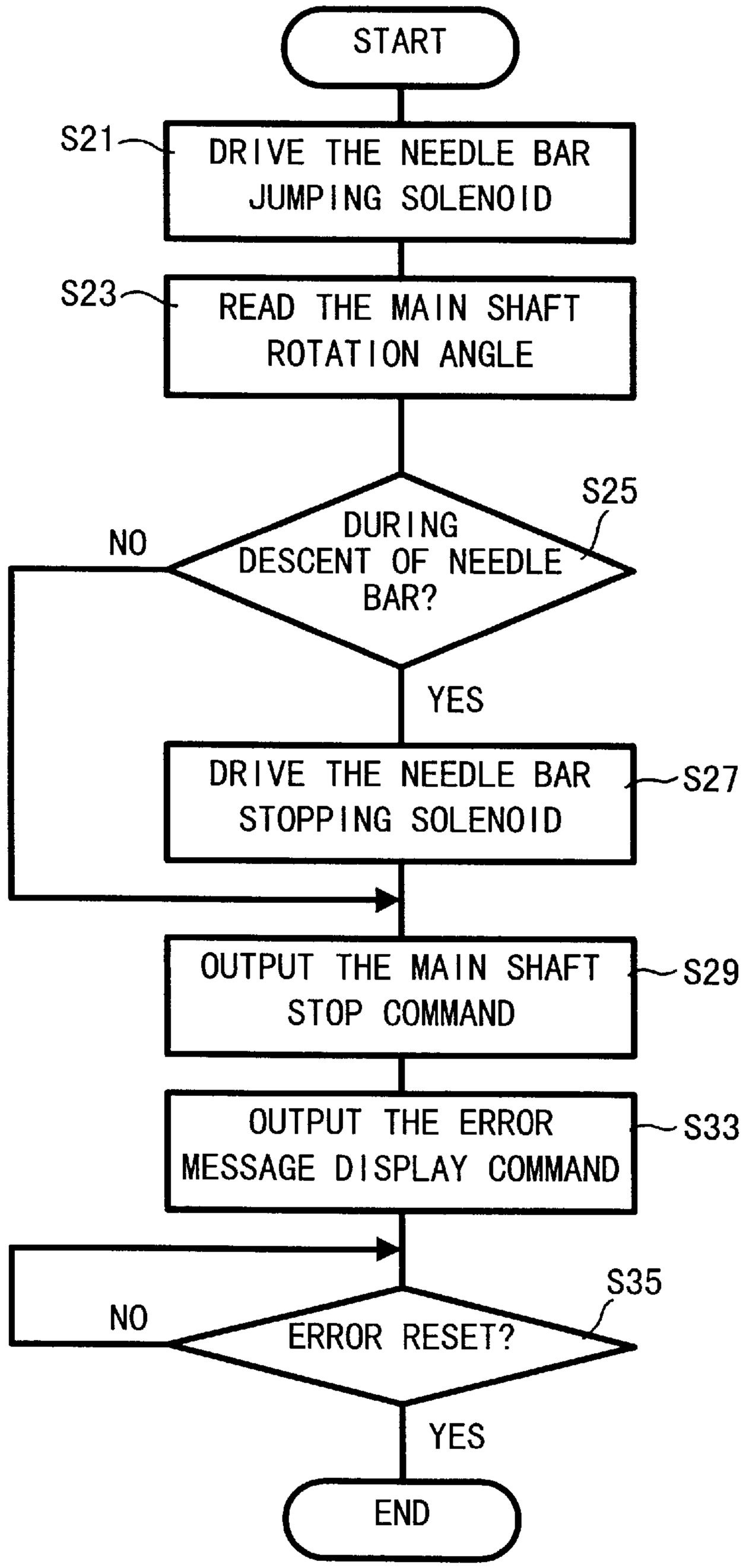
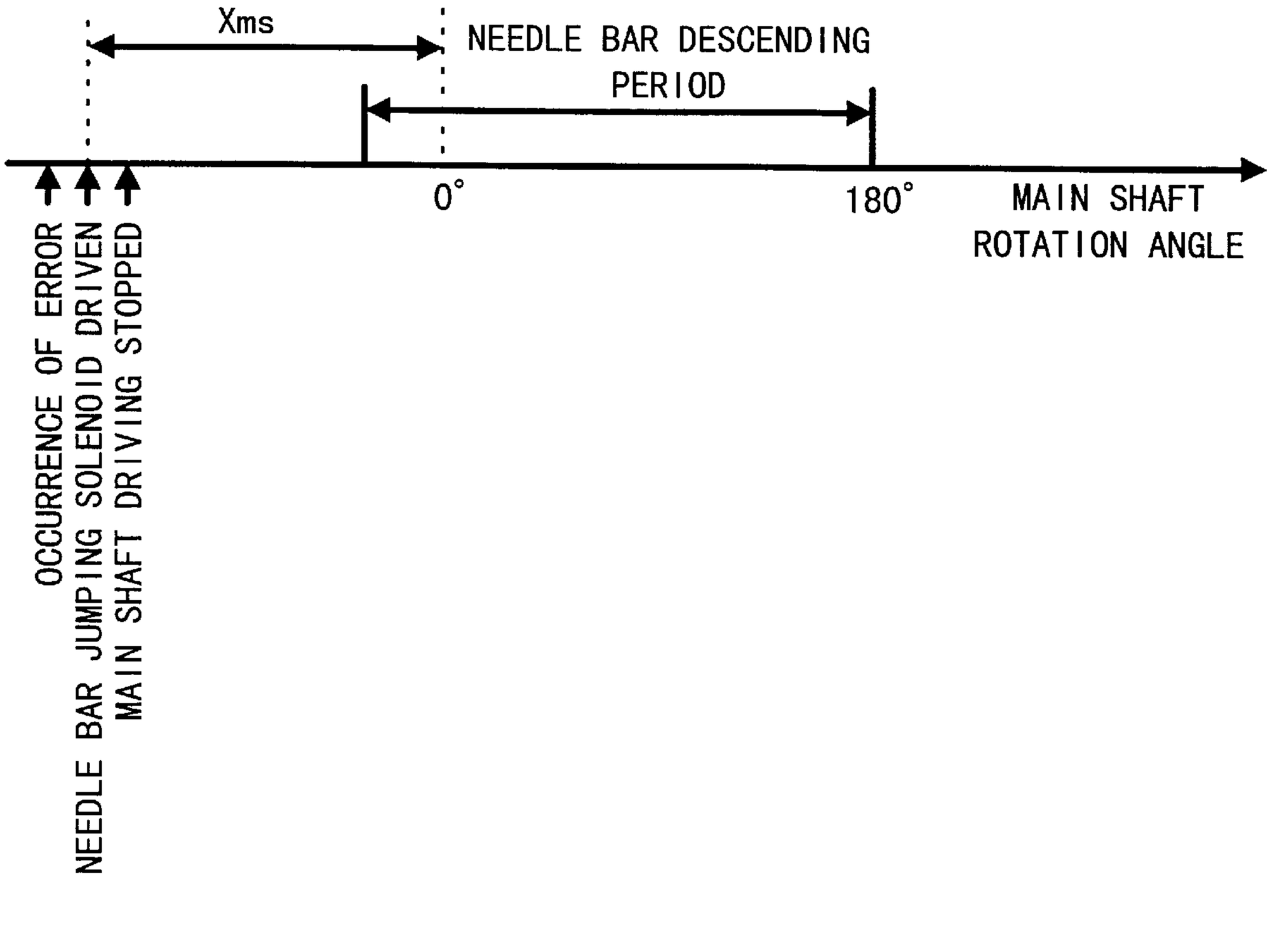

START
S21
DRIVE THE NEEDLE BAR JUMPING SOLENOID
S23
READ THE MAIN SHAFT ROTATION ANGLE
S25
DURING DESCENT OF NEEDLE BAR?
NO
YES
DRIVE THE NEEDLE BAR STOPPING SOLENOID
S27
OUTPUT THE MAIN SHAFT STOP COMMAND
S29
OUTPUT THE ERROR MESSAGE DISPLAY COMMAND
S33
S35
NO
ERROR RESET?
YES
END

Fig. 8


Xms
NEEDLE BAR DESCENDING PERIOD
0°
180°
MAIN SHAFT ROTATION ANGLE
OCCURRENCE OF ERROR
NEEDLE BAR JUMPING SOLENOID DRIVEN
MAIN SHAFT DRIVING STOPPED

NEEDLE BAR STOPPER FOR USE IN A SEWING MACHINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a needle bar stopper for use in a sewing machine having a main shaft and a needle bar which moves vertically upon reception of a driving force from the main shaft.

2. Description of the Related Art

In embroidery machines recently proposed in the field of embroidery machines, a needle bar case containing a number of needle bars arrayed side by side is provided at a head. The needle bars are selected one by one sequentially and vertically moved to stitch a multi-color embroidery pattern. In embroidery machines of this kind, the needle bar to which a driving force is transmitted from a main shaft is replaced by stopping the needle bar at its upper dead point and by sliding the needle bar case. It is common practice in the field of embroidery machines to stop the needle bar, even if it is only one needle bar, near its upper dead point when a thread breakage occurs or when needle bar jump is performed.

In addition, sewing machines recently proposed in the field of general sewing machines are provided with a main shaft motor which drives a main shaft and a separate loop-catcher drive motor which rotationally drives a loop catcher. In sewing machines of this kind, the main shaft motor and the loop-catcher drive motor are controlled to operate in synchronism with each other, and if they get out of synchronism, the needle bar may interfere with the loop catcher. To avoid this, it is preferable to stop the needle bar near its upper dead position when the above-mentioned asynchronism occurs.

As a needle bar stopper for these various sewing machines, a device having, for example, the following structure has been proposed. The device comprises a vertically movable segment which vertically moves upon reception of a driving force from the main shaft and which is also laterally swingable, and an engaging projection projecting from the vertically movable segment toward the needle bar and engageable with a linking pin of the needle bar. In order for the device to stop the needle bar, the vertically movable segment is swung by, for example, a solenoid to disengage the engaging projection from the linking pin. When such disengagement takes place, the driving force is stopped from being transmitted from the main shaft to the needle bar. In addition, the needle bar is usually urged upward by a compression spring. Accordingly, when the above disengagement takes place, the needle bar moves upward by a biasing force of the compression spring.

However, since the needle bar has certain inertia, prohibiting the transmission of the driving force to the needle bar by the above disengagement is not always enough to stop the needle bar. For example, when the above disengagement takes place while the needle bar is descending, the needle bar continues descending due to the inertia. In this case, jumping the needle bar may cause the needle bar to be caught in a material being sewn or to interfere with the loop catcher.

SUMMARY OF THE INVENTION

In view of the foregoing, an object of the invention is to provide a needle bar stopper which is used in a sewing machine and can stop a needle bar reliably.

To achieve this object, a needle bar stopper according to the invention is used in a sewing machine having a main shaft and a needle bar which moves vertically upon reception of a driving force from the main shaft. The needle bar stopper for stopping the needle bar comprises a transmission prohibiting unit which prohibits transmission of the driving force from the main shaft to the needle bar, and a braking unit which applies a braking force to the needle bar when transmission of the driving force from the main shaft to the needle bar is prohibited.

With the above structure, the transmission prohibiting unit prohibits transmission of a driving force from the main shaft to the needle bar. The braking unit applies a braking force to the needle bar when transmission of the driving force is prohibited by the transmission prohibiting unit. The needle bar is stopped reliably by not only prohibition of transmission of the driving force thereto but also application of the braking force thereto. Accordingly, the needle bar is effectively prevented from being caught in a material being sewn or from interfering with a loop catcher.

According to a preferred feature of the invention, the needle bar stopper may further comprise a moving direction detector which detects the needle bar moving direction, and the braking unit may be controlled to operate or not to operate based on a result of the detection by the moving direction detector.

Applying a braking force to the needle bar which is ascending is likely to prevent the needle bar from ascending, causing the needle bar to be caught in the material being sewn or to interfere with the loop catcher. Such trouble is effectively prevented by the needle bar stopper structured as described above, where the braking unit is controlled to operate or not to operate based on the needle bar moving direction detected by the moving direction detector, and applies a braking force while taking braking timing into account. Therefore, in the sewing machine to which the invention is applied, the needle is effectively prevented from being caught in the material being sewn or from interfering with the loop catcher.

According to another feature of the invention, the braking unit may be so arranged as to apply a braking force by pressing a member having a high friction coefficient against the needle bar.

If the above structure is employed, the needle bar can be braked reliably in quite a simple structure.

According to still another feature of the invention, the sewing machine may have a main shaft motor which rotationally drives the main shaft and a separate loop-catcher drive motor which rotationally drives the loop catcher, and the needle bar stopper may further comprise an asynchronism detector which detects asynchronism between the needle bar and the loop catcher. Additionally, the transmission prohibiting unit may be so arranged as to prohibit transmission of the driving force when the asynchronism detected by the asynchronism detector exceeds a predetermined threshold value.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will be described in detail with reference to the following figures wherein:

FIG. **1** is a perspective view showing a structure of an embroidery machine incorporating a needle bar stopper according to the invention;

FIG. **2** is a perspective view showing a structure of a driving mechanism of the embroidery machine;

FIG. **3** is a plan view showing a structure and operation of the driving mechanism of the embroidery machine;

FIG. **4** is a plan view showing a structure of a bed of the embroidery machine;

FIG. **5** is a block diagram showing a structure of a control system of the embroidery machine;

FIG. **6** is a flowchart showing loop-catcher shaft driving control executed by the control system;

FIG. **7** is a flowchart showing error handling executed by the control system; and

FIG. **8** is an illustrative diagram showing the principle of judgment of the needle bar descending period in the error handling.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

An embroidery machine according to a preferred embodiment of the invention will be described while referring to the drawings.

FIG. **1** is a perspective view showing the structure of an embroidery machine incorporating a needle bar stopper according to the invention. The embroidery machine is a three-head embroidery machine as shown below.

As shown in FIG. **1**, the embroidery machine has a laterally extending base frame **1**. A laterally extending support frame **3** stands at the top rear of the base frame **1**. On the support frame **3**, three heads **4**, **5**, **6** are provided at predetermined intervals. Provided on the upper surface of the base frame **1** are beds **7**, **8**, **9** which respectively oppose the heads **4**, **5**, **6**.

At the front end of each of the heads **4**, **5**, **6**, a case **12** is laterally movably supported. Twelve needles aligned in a row are vertically movably supported in each case **12**. At the top front of the base frame **1**, a work table **13** is placed so that the work table is as high as the upper surfaces of the beds **7**, **8**, **9**. A rectangular workpiece holding frame **16** is provided at the top of the work table **13** and auxiliary tables **14**, **15** on both sides thereof. The workpiece holding frame **16** is so arranged as to hold a material being sewn **99** (FIG. **2**) and to move in the X-axis direction (laterally) and in the Y-axis direction (forward and backward). In addition, provided at the rear of one auxiliary table **14**, **15** are a display **18**A which displays a message about sewing and an operation panel **18** from which various commands are executed.

Referring now to FIGS. **2** and **3**, described below is the structure of a driving mechanism **20** which vertically moves any one of needle bars **19**. A needle **11** is attached to the lower end of each needle bar **19**. A head frame **50** (FIG. **3**) is attached to the tip of each head **4** to **6**. The upper and lower ends of a vertically placed master needle bar **21** are fixed to the front end of each head frame **50**.

At the master needle bar, a vertically movable segment **22** is vertically movably provided to vertically move any one of the needle bars **19** via a linking pin **19**A which is fixed to each needle bar **19**. At the lower end of the vertically movable segment **22**, there is provided a driving member **23** which moves integrally with the vertically movable segment **22**. The vertically movable segment **22** is provided rotatably about the master needle bar **21** with reference to the driving member **23**. At the rear of the driving member **23**, a swing lever **25** is provided swingably around a pivot shaft **24** which is horizontally supported within each head frame **50**. One end of the swing lever **25** is connected to the driving member **23** via a link **26**.

On the other hand, an eccentric cam **28** is fixed to a main shaft **27** which is provided laterally through the head frames **50** of the heads **4** to **6**. The lower end of an eccentric lever **29** fitted over the eccentric cam **28** is connected to the swing lever **25**. The swing lever **25** is swingable around the pivot shaft **24**. Accordingly, the eccentric lever **29** moves vertically as the main shaft **27** rotates and the vertical movement is transmitted to the vertically movable segment **22** via the swing lever **25**, link **26**, and driving member **23**.

At the vertically movable segment **22**, there is provided a pair of engaging projections **22***a* and **22***b* which engage with the linking pin **19***a* at its top and bottom. When the engaging projections **22***a* and **22***b* are engaged with any one of the linking pins **19***a*, vertical movement of the vertically movable segment **22** is transmitted to the corresponding needle bar **19** and needle **11**. In addition, at the upper portion of the vertically movable segment **22**, a spring receiving member **35** is vertically movably seated around the master needle bar **21**. The vertically movable segment **22** is rotationally urged by a coil spring **36**, which is provided between the spring receiving member **35** and the vertically movable segment **22**, to the linking position shown by a solid line in FIGS. **2** and **3**. In other words, the engaging projections **22***a* and **22***b* are urged around the master needle bar **21** so as to face the needle bar **19** and engage with the linking pin **19**A.

As shown in FIG. **2**, the needle bars **19** are vertically movably supported by support frames **12**A and **12**B of the needle bar case **12**. A compression spring **40** is put around each needle bar **19** and between the lower support frame **12***b* and each linking pin **19***a*. Each needle bar **19** is urged upward by a biasing force of each compression spring **40**.

A directly driven needle bar jumping solenoid **41** is provided on the left wall of each head frame **50**, and a swing lever **43**, which is L-shaped in the plan view, is provided between the needle bar jumping solenoid **41** and the vertically movable segment **22**. The swing lever **43** is horizontally swingably supported by a screw **44** inserted thereinto. One end of the swing lever **43** is connected to a plunger **41***a* of the needle bar jumping solenoid **41**. An engaging portion **22**D projects from the one side (the left side as viewed from an operator's position) of the engaging projection **22**B beneath the vertically movable segment **22**. An actuating rod **45** engageable with the engaging portion **22***d* projects downward from the other end of the swing lever **43**. The actuating rod **45** is formed as a tube having a height in accordance with the vertically moving distance of the needle bar **19** in order to engage the engaging portion **22**D wherever the needle bar **19** is positioned.

Therefore, when the needle bar jumping solenoid **41** is energized to project the plunger **41***a*, the swing lever **43** swings as shown by a two dotted chain line in FIG. **3** and the actuating rod **45** pushes against the engaging portion **22**D. Accordingly, the vertically movable segment **22** swings around the master needle bar **21** to release the engaging projections **22**A, **22**B from the linking pin **19**A. At this time, the driving force is stopped from being transmitted from the main shaft **27** to the needle bar **19**. When the needle bar jumping solenoid **41** is no longer energized, the swing lever **43** swings back by the action of a tension spring **46** (FIG. **3**) provided between the swing lever **43** and the head frame **50**, as the actuating rod **45** retracts. Then, the vertically movable segment **22** is swung to the position shown by a solid line in FIG. **3** by the action of the coil spring **36**, and the engaging projections **22**A and **22**B again engage with one of the linking pins **19**A enabling the associated needle bar **19** to be vertically driven.

At the upper portion of each head frame **50**, a swing plate **47** is swingably provided via a hinge **47**A. The swing plate

47 is formed to be a flat plate which is generally perpendicular to the forward and backward direction of the embroidery machine and longer in the lateral direction. A plunger 48A of a needle bar stopping solenoid 48 is connected to the end opposite to the end where the hinge 47A is provided. The needle bar stopping solenoid 48 is also fixed to the head frame 50. As previously described, the engaging projections 22A and 22B engage with only one of the needle bars 19 according to the position of the needle bar case 12, enabling the appropriate needle bar 19 to be vertically moved. A rubber piece 49 is fixed to the front of the swing plate 47 so as to be opposite to the needle bar 19 being used.

Accordingly, when the needle bar stopping solenoid 48 is energized to project the plunger 48A, the swing plate 47 swings forward, as shown by a two dotted chain line in FIG. 3, to press the rubber piece 49 against the needle bar 19 in use. Thus, a braking force is applied to the needle bar 19. When the needle bar stopping solenoid 48 is no longer energized, the swing plate 47 retracts to disengage the rubber piece 49 from the needle bar 19, enabling the needle bar 19 to be vertically moved.

Referring now to FIG. 4, described below is a structure of each of the beds 7, 8, 9. Since each of the beds 7, 8, 9 has the same structure, the bed 7 at the left end is described. The rear end of a bed case 51 which extends forward and backward and has a generally U-shaped section is attached to the support frame 3. The top front end of the bed case 51 is covered by a throat plate 52. A loop-catcher module 55 is detachably fixed to the front end of the bed case 51.

The loop-catcher module 55 comprises a loop-catcher drive motor 58 formed of a stepping motor and a loop catcher 59 provided directly under the vertically moving needle bar 19. A drive shaft 58A of the loop-catcher drive motor 58 and a loop-catcher shaft 60 fixed to the loop catcher 59 are connected via a coupling 61. The coupling 61 is a known coupling which interconnects a first linking member 62 attached to the rear end of the loop-catcher shaft 60 and a second linking member 63 attached to the drive shaft 58A. A disc encoder 64 is attached to the second linking member 63. A second encoder sensor 65, formed of a photosensor which optically detects a plurality of slits formed on the disc encoder 64, is provided on the side wall of the bed case 51. In addition, a bearing case 70 to which a bearing 71 is press-fitted is put around the loop-catcher shaft 60.

As shown in FIG. 5, built into the base frame 1 are an X-axis motor 91 and a Y-axis motor 93 which move the workpiece holding frame 16 in the X-axis and Y-axis directions, respectively, a main shaft motor 95 which drives the main shaft 27, and a needle bar change motor 97 which laterally moves the needle bar case 12. These motors 91, 93, 95, 97 are connected to an embroidery machine control circuit 100 which is also built into the base frame 1. Described below is a control system of the embroidery machine according to the invention.

The embroidery machine control circuit 100 is designed to control the embroidery machine entirely except for the loop catcher driving control, and is formed of a known microcomputer mainly comprising a central processing unit (CPU) 100A, a read only memory (ROM) 100B and a random access memory (RAM) 100C. The above-mentioned motors 91, 93, 95, 97 are connected to the embroidery machine control circuit 100 via driving circuits 101, 103, 105, 107, respectively, and the following devices are also connected thereto.

For the head 4, the above-mentioned needle bar jumping solenoid 41, needle bar stopping solenoid 48, and a presser foot drive solenoid 111 for vertically moving a presser foot 109 (FIG. 2) are connected to the embroidery machine control circuit 100 via the driving circuits 113, 115, 117, respectively, and a thread breakage sensor 118 for detecting a thread breakage in the head 4 is also connected thereto. For the heads 5, 6, these devices are connected in the same manner to the embroidery machine control circuit 100. For the main shaft motor 95, connected to the embroidery machine control circuit 100 are a first encoder sensor 122 which outputs 1000 slit signals per rotation of the main shaft motor 95, a main shaft origin sensor 123 which outputs one main shaft origin signal per 1000 slit signals of the first encoder sensor 122, i.e., one rotation of the main shaft motor 95, and a stop position sensor 124 which detects the stop position of the needle bar 19 (the position attained when the main shaft 27 rotates approximately 100° from its upper dead point).

In addition, a loop-catcher shaft control circuit 150, which performs driving control and thread cutting control of the loop catcher 59, is connected to the embroidery machine control circuit 100. The loop-catcher shaft control circuit 150 is formed of a microcomputer mainly comprising a CPU 150A, ROM 150B, and RAM 150C. For the bed 7, the loop-catcher drive motor 58 is connected to the loop-catcher shaft control circuit 150 via a driving circuit 154. Also connected thereto are the above-mentioned second encoder sensor 65 which outputs 50 slit signals per rotation of the disc encoder 64 and a loop-catcher shaft origin sensor 155 which outputs one loop-catcher shaft synchronizing signal per rotation of the disc encoder 64. For the beds 8, 9, they are connected in the same manner to the loop-catcher shaft control circuit 150. In addition, a thread cutting motor 88, which drives a thread cutter (not shown) to cut a needle thread, is connected to the loop-catcher shaft control circuit 150 via a driving circuit 156. The above-mentioned first encoder sensor 122, main shaft origin sensor 123, and stop position sensor 124 are also connected thereto.

Referring now to the flowchart of FIG. 6, a routine for loop-catcher shaft driving control executed by the loop-catcher shaft control circuit 150 is described. Prior to discussing the control, the signals output from the embroidery machine control circuit 100 to the loop-catcher shaft control circuit 150 are described. When sewing is started, the main shaft 27 is stopped at the above-mentioned stop position while the needle bar 19 is disengaged from the vertically movable segment 22 and positioned at its upper dead point. When sewing is executed according to the embroidery data containing stitch position data for N stitches, the embroidery machine control circuit 100 starts driving the main shaft motor 95 while outputting a main shaft driving signal at a "H" level. When sewing for N stitches is completed, the embroidery machine control circuit 100 changes the main shaft driving signal to a "L" level, stops the main shaft 27 at the above-mentioned stop position, and outputs a thread cutting signal.

The loop-catcher shaft control circuit 150 starts the loop-catcher shaft driving control when power is turned on. First, in S1 (hereinafter, S stands for a step), various data is initialized. Here, timers and counters to be used for the control are reset. Subsequently, in S3, main shaft/loop-catcher shaft initial setting is executed. Here, the loop-catcher shaft drive motor 58 is driven to position the loop-catcher shaft 60 to its origin where the loop-catcher shaft synchronizing signal is output from the loop-catcher shaft origin sensor 155. The loop-catcher drive motor 58 is not driven until the main shaft 27 is judged to be at its stop position by the stop position sensor 24. When the main shaft

27 is not at its stop position, the embroidery machine control circuit **100** displays an error message on the display **18**A to prompt the operator to manually rotate the main shaft **27** to its stop position.

When the main shaft **27** has been positioned at its stop position and the loop-catcher shaft **60** has been positioned at the above-mentioned origin (S**3**), the loop-catcher shaft control circuit **150** judges, in S**5**, whether the main shaft driving signal output from the embroidery machine control circuit **100** is at the "H" level. When it is at the "L" level (NO), control loops at that point until the "H" level is recognized. When it is at the "H" level (YES), S**7** is reached, where whether the embroidery machine control circuit **100** has output the thread cutting signal is determined. When no thread cutting signal has been output (NO), S**9** is reached, where the rotation angle of the main shaft **27** is read. In S**11**, the control circuit **150** judges whether it is time to drive the loop-catcher shaft **60** according to the rotation angle. If it is so (S**11**: YES), the loop-catcher drive motor **58** is driven to rotate by one step (S**13**) and control returns to S**5**.

If it is not time for loop-catcher shaft **60** driving (S**11**: NO), S**15** is reached, where the control circuit **150** judges whether asynchronism between the main shaft **27** and the loop-catcher shaft **60** is within the allowable range in comparison between the number of driving pulses output so far to the loop-catcher drive motor **58** and the rotation angle read in S**9**. When they are asynchronous with each other within the allowable range (S**15**: YES), control returns to S**5** and the above-mentioned steps are repeated. When S**5** to S**15** are repeated, stitches are formed on the material being sewn by the needle **11** and the loop catcher **59** which operate in cooperation with each other. When the embroidery machine control circuit **100** outputs the thread cutting signal upon the completion of sewing for N stitches, the determination in S**7** is YES and S**17** is reached. In S**17**, the loop-catcher shaft control circuit **150** rotates the loop-catcher shaft **60** by a predetermined angle to reserve the remaining needle thread and drives the thread cutting motor **88** to execute needle thread cutting and ending process, and the routine comes to an end.

Described above is the routine executed by the loop-catcher shaft control circuit **150** during normal sewing. If the main shaft **27** and the loop-catcher shaft **60** become asynchronous excessively for some reason, the determination in S**15** is NO and S**19** is reached. In S**19**, the embroidery machine control circuit **100** is directed to execute error handling and the routine comes to an end. When the routine ends in this way, the loop-catcher shaft control circuit **150** also executes the process for stopping the loop-catcher drive motor **58**.

Referring now to the flowchart of FIG. **7**, described below is error handling executed by the embroidery machine control circuit **100**. When error handling is started, the needle bar jumping solenoid **41** is driven for a predetermined period in S**21**. Then, the vertically movable segment **22** is disengaged from the linking pin **19**A, as described before, and the driving force is stopped from being transmitted to the needle bar **19**. In S**23**, the rotation angle of the main shaft **27** is read via the above-mentioned first encoder sensor **122** and main shaft origin sensor **123**. Subsequently, in S**25**, the embroidery machine control circuit **100** determines whether the above-mentioned disengagement timing determined by S**21** is provided when the needle bar **19** is descending.

As shown in FIG. **8**, when erroneous asynchronism occurs (S**15**: NO), the needle bar jumping solenoid **41** is driven (S**21**). There is a delay (X ms) between output of the driving signal and the actual disengagement. This delay mainly results from the operating time of the needle bar jumping solenoid **41**. When the main shaft **27** stopping process is executed in S**29**, which will be described later, after the driving signal is output in S**21**, the main shaft **27** decelerates abruptly to a stop; however it rotates by a certain degree. Because of this, the control circuit **100** predicts, in S**25**, whether the disengagement timing after the elapse of the above-mentioned delay (X ms) occurs during descent of the needle bar **19**.

When judgment is YES in S**25**, control proceeds to S**27**, where the needle bar stopping solenoid **48** is driven. Then, the rubber piece **49** is pressed against the needle bar **19** as described before and a braking force is transmitted to the needle bar **19**. When judgment is NO in S**25** or after S**27**, control proceeds to S**29** where a main shaft stop command is issued to the driving circuit **105**. Then, the main shaft motor **95** is stopped immediately.

Subsequently, an error message is displayed on the display **18**A in S**33**, and control waits for the error to be removed in S**35**. When the operator removes the error by operating, for example, the error reset switch on the operation panel **18** (S**35**: YES), the error handling routine comes to an end. Then, various controls including the loop catcher driving control shown in FIG. **6**, can be restarted.

As described above, when the main shaft **27** and the loop-catcher shaft **60** becomes asynchronous beyond the allowable range (S**15**: NO) in the embroidery machine, the driving force of the main shaft **27** is prohibited from being transmitted to the needle bar **19** (S**21**), and a braking force is applied to the needle bar **19** by means of the rubber piece **49** (S**27**). Accordingly, the needle bar **19** can be stopped reliably, and the needle **11** can be effectively prevented from interfering with the loop catcher **59**. Furthermore, since the braking force is applied to the needle bar **19** (S**27**) only when it is descending (S**25**: YES), there is no chance that braking prevents the needle bar **19** from ascending. Therefore, interference between the needle bar **19** and the rotary shaft **59** is prevented more effectively.

In the above preferred embodiment, the needle bar jumping solenoid **41**, swing lever **43**, and step S**21** by the embroidery machine control circuit **100** correspond to a transmission prohibiting unit; the needle bar stopping solenoid **48**, swing plate **47**, rubber piece **49**, and step S**27** by the embroidery machine control circuit **100** correspond to a braking unit; the first encoder sensor **122**, main shaft origin sensor **123**, and step S**25** by the embroidery machine control circuit **100** correspond to a moving direction detector; and the first encoder sensor **122**, main shaft origin sensor **123**, loop-catcher shaft origin sensor **155**, and step S**15** by the loop-catcher shaft control circuit **150** correspond to asynchronism detector.

The invention is not restricted to the particular forms in the foregoing embodiment and various modifications and alternations can be made thereto without departing from the scope of the invention. For example, an alternate structure for applying a braking force to the needle bar **19** is conceivable besides the one described above, in which the needle bar **19** is attracted by an electromagnet or in which braking is achieved by a biasing force of a high-compression spring provided separately from the compression spring **40** and actuated only during error handling. However, when a braking force is applied by pressing the rubber piece **49** (or an alternate member having a high friction coefficient, such as animal leather) against the needle bar **19**, as described

before, the needle bar **19** can be braked quite reliably with a simple structure. Consequently, the needle bar **19** can be stopped more reliably. Simultaneously the embroidery machine is simplified and the production cost is reduced.

In addition, the needle bar **19** stopping control, shown in the flowchart in FIG. **7**, may be executed when color change or skip stitch (needle bar jump) is executed, or when a thread breakage occurs. In this case, the needle bar **19** can be effectively prevented from being caught in and/or from forming excessive holes in the material being sewn **99**. Moreover, the invention can be applied to various sewing machines, besides embroidery machines, such as those where a main shaft motor and a loop-catcher shaft are connected by means of, for example, a belt. The angle at which a braking force is applied to the needle bar **19** may be set in the range free from interference with the loop catcher **59** within the needle bar **19** descending travel.

What is claimed is:

1. A needle bar stopper for use in a sewing machine having a main shaft and a needle bar which moves vertically upon reception of a driving force from the main shaft, the needle bar stopper for stopping the needle bar comprising:

a transmission prohibiting unit which prohibits transmission of the driving force from the main shaft to the needle bar; and

a braking unit which applies a braking force to the needle bar when transmission of the driving force from the main shaft to the needle bar is prohibited, wherein the needle bar stopper further comprises a moving direction detector which detects the needle bar moving direction, and the braking unit is controlled to operate based on a result of detection by the moving direction detector.

2. The needle bar stopper for use in a sewing machine as claimed in claim **1**, wherein the braking unit applies a braking force by pressing a member having a high friction coefficient against the needle bar.

3. The needle bar stopper for use in a sewing machine that further includes a main shaft motor which rotationally drives the main shaft and a separate loop-catcher drive motor which rotationally drives a loop catcher as claimed in claim **1**, further comprising an asynchronism detector which detects asynchronism between the needle bar and the loop catcher; and the transmission prohibiting unit prohibits transmission of the driving force when asynchronism detected by the asynchronism detector exceeds a predetermined threshold value.

4. The needle bar stopper for use in a sewing machine as claimed in claim **1**, wherein the braking unit applies a braking force to the needle bar when the moving direction detector detects the needle bar moving downward.

5. The needle bar stopper for use in a sewing machine as claimed in claim **2**, wherein the braking unit is formed of a solenoid which presses the member having a high friction coefficient against the needle bar.

6. The needle bar stopper for use in a sewing machine as claimed in claim **2**, wherein the member having a high friction coefficient is formed of a polymeric member.

7. The needle bar stopper for use in a sewing machine as claimed in claim **1**, further comprising a needle bar jumping solenoid.

8. A needle bar stopping mechanism for use in a sewing machine having a loop catcher, the needle bar stopping mechanism comprising:

a needle bar having a linking pin;

a needle bar drive mechanism having an engaging portion for selectively engaging the linking pin;

a needle bar braking mechanism for applying a braking force to the needle bar;

a synchronization detector for detecting asynchronous behavior between operation of the needle bar and the loop catcher; and

a needle bar direction of movement sensor for determining a direction of movement of the needle bar.

9. The needle bar stopping mechanism as claimed in claim **8**, wherein the needle bar drive mechanism comprises:

a rotatable drive shaft;

an eccentric cam fixed to the drive shaft;

an eccentric lever having an annular part rotatably received on the eccentric cam and a lever part; and

a linkage between an end of the lever part of the eccentric lever and the engaging part, the engaging part driving the linking pin when selectively engaged causing the needle to reciprocatively move in the vertical direction.

10. The needle bar stopping mechanism as claimed in claim **8**, wherein the engaging portion has a contact member, and further comprises a disengagement mechanism for causing the selective engagement of the engaging portion of the needle bar drive mechanism with the linking pin.

11. The needle bar stopping mechanism as claimed in claim **10**, wherein the disengagement mechanism comprises:

a needle bar jumping solenoid having an engagement rod;

a swing lever having a substantially L-shape when viewed in plan, one leg of the swing lever in contact with the engagement rod of the needle bar jumping solenoid;

an actuating rod extending from an end of the other leg of the swing lever to contact the contact member of the engaging portion; and

a force generating device for maintaining the one leg of the swing lever in contact with the engagement rod of the needle bar jumping solenoid.

12. The needle bar stopping mechanism as claimed in claim **11**, wherein the needle bar braking mechanism comprises:

a needle bar stopping solenoid having a plunger;

a swing plate rotatably mounted at one end to the sewing machine and contacting the plunger at the other end; and

a brake means mounted to a surface of the swing plate for engaging the needle bar.

13. The needle bar stopping mechanism as claimed in claim **12**, wherein the brake means is a pad for frictionally engaging the needle bar.

14. The needle bar stopping mechanism as claimed in claim **13**, wherein the pad is a polymeric material.

15. The needle bar stopping mechanism as claimed in claim **8**, further comprising a control unit, the control unit determining, based upon a signal from the synchronization detector, when the asynchronous behavior of the needle bar and the loop catcher is outside an allowable range for initiating error handling.

16. The needle bar stopping mechanism as claimed in claim **15**, wherein during error handling, the control unit stops operation of the loop catcher and initiates stopping of the needle bar.

17. The needle bar stopping mechanism as claimed in claim **16**, wherein the control unit determines whether the needle bar is descending based on a signal from the needle bar direction of movement sensor and, when the needle bar

is descending during error handling, activates the needle bar braking mechanism to stop the needle bar.

18. A needle bar stopper for use in a sewing machine having a main shaft and a needle bar which moves vertically upon reception of a driving force from the main shaft, the needle bar stopper for stopping the needle bar comprising:

transmission prohibiting means for probiting transmission of the driving force from the main shaft to the needle bar; and

braking means for applying a braking force to the needle bar when transmission of the driving force from the main shaft to the needle bar is prohibited, wherein the braking means has a member having a high coefficient of friction that is pressed against the needle bar to apply a braking force.

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